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# The Gypsy Moth

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The gypsy moth (*Lymantria dispar* L.) is probably the most notorious insect pest of hardwood trees in the Eastern United States. Introduced into the Boston area from Europe in 1869, it is now distributed through most of Pennsylvania, north to Quebec, and south through Maryland (fig. 1). In the past few years remote infestations that arise from artificial introductions of the insect have been detected in at least 10 different States, some as far removed as Washington, Oregon, and California. Since 1970, noticeable defoliation has exceeded 500,000 acres annually. More than 1 million acres were defoliated in 1971–73 and 1977–78.

## Hosts

Gypsy moth larvae can feed on at least 500 species of shrubs and vines. In the East, favored trees include oak, apple, speckled alder, basswood, gray and river birch, poplar, willow, and hawthorne. Less favored are birch, hickory, maple, cherry, cottonwood, elm, blackgum, larch, sassafras, and hornbeam. Older larvae feed upon tree species that younger larvae normally avoid such as hemlock, southern white cedar, and the pines and spruces native to the East. The gypsy moth avoids ash, yellow-poplar, sycamore, butternut, black walnut, locust, catalpa, flowering dogwood, balsam fir, red cedar, American holly, and shrubs such as mountain laurel, rhododendron, and arborvitae. The host list will undoubtedly expand as the gypsy moth moves south and west.

## Damage

Since establishment in this country, the gypsy moth has

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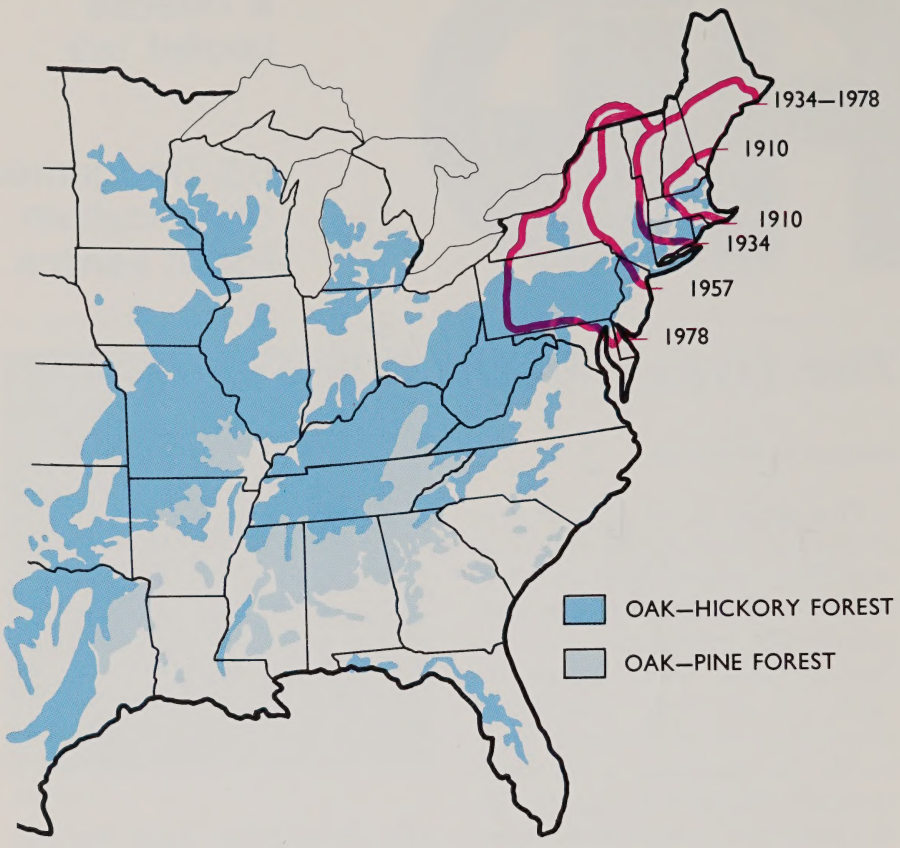


Figure 1.—Distribution and rate of spread of gypsy moth in relation to susceptible oak forest.

become more of a "people problem." Extensive defoliation of forested areas is unsightly and can be costly. In forested urban communities it is viewed as intolerable. Gypsy moth larvae are a major nuisance when they defoliate shade and ornamental trees and landscape plantings, crawl on and around houses (fig. 2), and leave debris from their feeding on pools and patios.

The effects of gypsy moth defoliation are varied, and depend on many factors. The most important are the condition of the tree before defoliation, the amount of foliage removed, and the number of consecutive defoliations. When more than 50 percent of the foliage is consumed, oaks and most other species will refoliate in midsummer. This refoliation uses energy reserves and eventually weakens the tree. Weakened trees exhibit symptoms such as dieback of twigs and branches in the upper crown and sprout-

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Figure 2.—Nuisance associated with infestations around homes.

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Figure 3.—Dead oak tree with white fans of shoestring root rot fungus.

ing of old buds on the trunk and larger branches.

The diametric growth of defoliated trees may be reduced by 30 to 50 percent. Healthy trees can usually withstand one or two consecutive defoliations, but trees in poor condition or subject to other stresses usually succumb after two or three consecutive defoliations and may die after a single defoliation. Weakened trees are usually attacked and eventually killed by opportunistic organisms such as the shoestring fungus, *Armillaria mellea* (fig. 3), and the two-lined chestnut borer, *Agrilus bilineatus*.

The susceptibility of a forest stand to defoliation by the gypsy moth depends on the abundance of favored food species (mainly oaks) and on site and stand conditions. Forest stands that undergo frequent environmental disturbance and stress—such as sand flats and rocky ridges—frequently incur repeated severe defoliations. Trees growing on these disturbed sites also possess many structural features that favor the survival of gypsy moths (fig. 4). Forest stands on protected slopes or on sites where moisture and organic matter are adequate are usually more resistant to defoliation.

Some generalizations can be made about the vulnerability of forest stands to tree mortality after defoliation:

- Slow-growing trees on disturbed open sites may survive repeated defoliation better than fast-growing trees on well-stocked, better sites.

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Figure 4.—Typical susceptible stand on a dry, rocky ridge. Trees are scrubby, deformed, and have many bark flaps and deep fissures that favor survival of the gypsy moth.

- Oak mortality has been greater (20 to 60 percent) in recently invaded stands in New Jersey and Pennsylvania than in stands in Connecticut and Rhode Island (less than 20 percent) that were infested in the past.
- Tree mortality is apparently related to the proportion of oak in the stand, and is therefore more pronounced in mixed oak stands than in oak-pine or mixed hardwoods (least vulnerable). Subdominant trees are more likely and more rapidly killed than dominant trees.
- Repeated outbreaks may reduce the proportion of oak in many stands and thus produce a residual stand that is more resistant to gypsy moth.

## Life Stages and Development

There is one generation of gypsy moth per year. Larvae begin to emerge from egg masses in late April or early May. The first hatch is determined primarily by temperature and coincides with budbreak of most hardwood trees. Eggs in an individual egg mass hatch in 3 to 5 days, but in an infested area they hatch over a period of 2 to 3 weeks. Newly hatched larvae (fig. 5), which are buff-colored but turn black within a few hours, are less than 2 mm long and have long lateral hairs. They remain on or around the egg mass for several days if it is raining or cold (below 40°F or 4°C).

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Figure 5.—Egg mass with newly hatched larvae; buff-colored larvae have most recently emerged.

When conditions are favorable, larvae leave the egg mass and climb trees or other objects in response to overhead light, trailing silken threads continuously as they move. When larvae reach the branches at the top or perimeter of trees, they do not feed but drop on the silken threads and are then dispersed by slight gusts of wind. Larvae may go through several dispersal episodes before settling down to feed. Some larvae may be carried for long distances by wind but most are distributed within relatively local areas.

Male larvae usually pass through five instars, and females through six. Each instar lasts 4 to 10 days depending on the temperature during each stage of development. Coloration of larvae begins to appear in the third instar. Older larvae have distinct markings on their upper side—a double row of five pairs of blue spots followed by a double row of six pairs of red spots.

During the first three instars, larvae alternate feeding and resting during the day. First-instar larvae chew small holes in the leaf and rest on a mat of silken threads they have made on the underside of the leaf. Second- and third-instar larvae feed at the leaf margins and rest beneath branches and twigs. After larvae molt to the fourth instar, their behavior changes dramatically. They feed at night and then descend the trees at dawn where they rest in protected locations for the remainder of the day. At dusk, the larvae again climb the tree to feed. Movement up and down the tree is triggered by changing light intensity. The silken threads trailed by the larvae are used to return to the resting sites.

Larvae prefer to rest under bark flaps or in the holes and wounds (fig. 6) of trees. This behavior protects them from natural enemies such as birds and parasites that are active during the day. If no protected sites are available, the larvae will descend to the ground and rest beneath leaf litter, dead stumps, or other nearby objects. Here, however, they are vulnerable to predation by shrews and other small mammals that forage on or near the ground. At high insect densities, the larvae

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Figure 6.—Disfigured oak on poor site has wounds that gypsy moth larvae use for shelter.

do not migrate but remain on the foliage and feed continuously day and night. When defoliation is complete, larger larvae actively wander in search of food and move from defoliated woodlands to adjacent populated areas.

Larvae usually complete their development by early July, and then remain in the same location and pupate for about 2 weeks. In dense populations, clumps of pupae can be found at the base of branches, in crotches, in bark fissures, or attached to the bark surface. The mahogany-colored pupae are immobile, defenseless, and vulnerable to many different predators and parasites.

The male gypsy moth adult is dark brown and has wavy dark bands across its forewings (fig. 7). Males emerge before females, are strong fliers, and are usually most active within the forest canopy during daylight. They fly in rapid zigzag patterns and search up and down tree trunks for female moths.

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Figure 7.—Male gypsy moth.

The female moth is nearly white and has wavy dark bands across its forewings (fig. 8). Females do not fly but crawl short distances from the place they emerged. Shortly thereafter they release a potent sex attractant to allure male moths. Soon after mating the female deposits her eggs in a single well-formed mass, usually near where she pupated, and dies.

The egg masses, which are encased in a secretion produced by the female moth, contain 75 to 1,000 eggs. They are buff-colored when first laid but may bleach out over the winter months when exposed to direct sunlight and weathering. Within 4 to 6 weeks, the embryos develop into larvae that overwinter in the eggs and hatch the following spring.

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Figure 8.—Female gypsy moth.

## Natural Control

The gypsy moth was introduced into this country without its complement of natural enemies. Millions of dollars have been spent in efforts to control or eliminate gypsy moth populations and to retard its natural and artificial spread.

Early in this century, a foreign exploration program was initiated to locate parasites and predators in Europe and Asia and to establish them in this country. Through this program, which is still active, 10 parasites and 2 invertebrate predators have been established. Collectively, these species, along with native parasites and predators, are important in keeping gypsy moth populations sparse and in accelerating population collapses.

Of the two species of parasites that attack gypsy moth eggs, *Ooencyrtus kuvanae* is the most widespread and may destroy up to 50 percent of the eggs in smaller egg masses. *Apanteles melanoscelus* is a wasp that commonly parasitizes young larvae, but its effectiveness is hindered because it is attacked by 16 species of hyperparasites.

Three species of tachinid flies that attack larger gypsy moth larvae have been abundant both in increasing and declining gypsy moth populations, and have caused over 60 percent parasitism both in this country and in parts of Europe. *Compsilura concinnata* larviposits one to five larvae in each host larva. *Blepharipa pratensis* lays small eggs on foliage of preferred hosts which are consumed by the late-instar larvae as they feed. *Parasetigena agilis* deposits its eggs near the thoracic region of host larvae—the parasite larvae emerge and bore into the host. Maggots of the three fly species develop to maturity within gypsy moth larvae and pupae, completely destroy their host, and then pupate in the soil.

One pupal parasite, *Brachymeria intermedia,* is established in this country but becomes abundant only when gypsy moth populations are at defoliating levels.

The total predator community that feeds on gypsy moth includes birds, mammals, amphibians, reptiles, and invertebrates. At least 38 species of birds feed on the gypsy moth during the various life stages. Chickadees, nuthatches, catbirds, and bluejays commonly eat gypsy moths when the insect is sparse. Other species such as cuckoos, starlings, redwinged blackbirds, and grackles are attracted to high-density gypsy moth areas because of the abundance of food.

Small mammals such as the white-footed mouse *(Peromyscus leucopus)* (fig. 9) and shrews (*Sorex* sp.) are important predators of gypsy moth larvae and pupae in sparse populations. At least 15 species of common woodland mammals, including chipmunks, squirrels, skunks, and raccoons, also eat gypsy moths. Species of

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Figure 9.—White-footed mice feeding on late-instar larvae.

ground beetles, including one imported from Europe *(Calasoma sycophanta)* (fig. 10), ants, spiders, and hemipterans also prey on gypsy moths.

The impact of predators on gypsy moth populations is affected by factors such as the availability of alternate food sources. Collectively, predators help keep sparse populations at inocuous levels, but like parasites, they probably have little effect on outbreak populations.

Many natural diseases caused by bacteria, fungi, and viruses affect the gypsy moth, especially when populations are at outbreak levels and are competing for a limited food source. The most devastating disease, caused by the specific nucleopolyhedrosis virus (NPV), can kill up to 70 percent of the larvae (fig. 11) and initiate total collapse of populations. Because of its effectiveness, it has been developed for use in gypsy moth management programs.

Weather may have an adverse effect on gypsy moth populations. In Maine, 85 percent of eggs were killed when winter temperatures dropped to -26° F (-32° C). Periods of thawing and freezing in midwinter may also have an adverse effect on overwintering embryos, causing them to prematurely expend energy reserves. Cold, rainy weather after spring hatching may inhibit dispersal of larvae and adversely affect their establishment on foliage.

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Figure 10.—This ground beetle is one of many predators that feed on gypsy moth larvae and pupae.

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Figure 11.—Virus-killed larvae characteristically hang by their prolegs.

## Applied Control

Although the gypsy moth continues to disperse slowly to the south and west of the current infestation, artificial spread of the insect has been retarded through enforcement of a Federal Domestic Quarantine. This includes the following tactics:

- Remote infestations that are detected outside of the infested area and that arise from accidental introductions are eliminated or suppressed to undetectable levels with insecticides.
- Interstate movement of articles that frequently harbor gypsy moth life stages, i.e. nursery stock, timber products, or firewood, is restricted. This material must be inspected and certified to be pest-free.
- Infested campgrounds and parks are sprayed with insecticides to reduce risk of gypsy moths being transported on recreational vehicles or camping equipment.

Within the infested area, State and Federal agencies rear and release both native and exotic parasites to help stabilize gypsy moth populations. Because of economic constraints and environmental concerns, and despite the magnitude of recent outbreaks, less than 10 percent of the defoliated area has been sprayed annually under State and Federal cooperative suppression programs. The purpose of this limited spraying is to reduce nuisance, protect foliage, and prevent tree mortality in forested residential communities and on high value and heavily used recreation lands. Several chemical insecticides and a microbial insecticide, *Bacillus thuringiensis,* are registered for control of the gypsy

moth. Gypchek, a product containing the natural nucleopolyhedrosis virus, is registered for use in State and Federal cooperative suppression programs.

Homeowners can conduct the following practices to alleviate the gypsy moth problem, especially when populations are sparse:

- To avoid stress, maintain good conditions for growing trees and diversify trees and plants whenever possible.
- Remove objects around the yard that provide shelter for gypsy moth larvae and pupae and increase their survival, e.g., bark flaps, dead branches and trees, boxes, cans, and old tires.
- Look for and destroy egg masses, larvae, and pupae in suspect locations such as wood piles, stone walls, and outbuildings.

If control is necessary, contact a County Cooperative Extension agent, State entomologist, or State Forester, nursery manager, arborist, or specialists at your State university or agricultural experiment station.

Although this report discusses research involving pesticides, such research does not imply that the pesticide has been registered or recommended for the use studied. Registration is necessary before any pesticide can be recommended. If not handled or applied properly, pesticides can be injurious to humans, domestic animals, desirable plants, fish, and wildlife. Always read and follow the directions on the pesticide container.

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